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DIET OF XANTUS'S MURRELETS IN THE SOUTHERN CALIFORNIA BIGHT

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ABSTRACT.—Most of what is known about diet of Xantus's Murrelets (*Synthliboramphus hypoleucus*) comes from prey found in 19 of 22 murrelet stomachs collected during the 1977 breeding season near Santa Barbara Island in the Southern California Bight (SCB). In May 2002, we examined stomachs of 10 Xantus's Murrelets collected near Anacapa Island, also within the SCB. Seven of the 10 stomachs contained prey. Prey were subadult or adult northern anchovy (*Engraulis mordax*; 2 stomachs), either juvenile bluefin driftfish (*Psenes pellucidus*) or medusafish (*Icichthys lockingtoni*; 2 stomachs), and euphausiids (*Thysanoessa spinifera*; 3 stomachs). Only one prey type was found in each stomach. Our sample added to the diversity of known prey types used in the SCB, including euphausiids and larger age/size classes of fish. We confirmed continued use of northern anchovy, and identified new prey species (bluefin driftfish or medusafish) associated with jellyfish or floating algae and debris in convergence lines. During the breeding season, Xantus's Murrelets appear to be generalist feeders that search for and use available prey that may be concentrated at convergence lines. *Received 3 November 2003, accepted 14 June 2004.*

In 2004, Xantus's Murrelet (*Synthliboramphus hypoleucus*) was listed by the state of California as a threatened species (Burkett et al. 2003). Knowledge of diet is essential for understanding their foraging ecology, variation in prey resources, at-sea distribution, and at-sea population threats; however, little is known about the diet of Xantus's Murrelet. These birds feed far from shore in small, dispersed groups, usually singles and pairs and occasionally in groups of up to eight birds (Hunt et al. 1979, Briggs et al. 1987, Drost and Lewis 1995, Whitworth et al. 2000). Most dietary information was derived from the examination of stomach contents from 19 of 22 murrelets collected during the 1977 breeding season near Santa Barbara Island, California (Hunt et al. 1979), within the Southern California Bight (SCB). Only larval fish were reported, including northern anchovy (*Engraulis mordax*), Pacific saury (*Cololabis saira*), and rockfish (*Sebastes* sp.). To increase our knowledge of the murrelet's diet, we evaluated nonlethal methods of obtaining dietary information. These techniques failed, and we resorted to using lethal methods to collect 10 murrelets off Anacapa Island in the SCB during April and May 2002. The dietary information that we obtained may contribute to the conservation of this species.

METHODS

Initially, we evaluated two non-lethal techniques to obtain stomach contents. First, on 20 April 2002 (01:00–02:00 PST), we used a night-lighting technique conducted from an inflatable boat to capture three Xantus's Murrelets from a nocturnal, at-sea congregation near Anacapa Island (Whitworth et al. 1997, 2003; C. D. Hamilton unpubl. data). Captured murrelets were returned to the support vessel, sedated with isoflurane by a veterinarian, and examined with a 2.7 mm endoscope video probe (Karl Storz Veterinary Endoscopy, Goleta, California) that was slowly passed through the mouth, esophagus, proventriculus, and into the gizzard. The digestive tracts of these murrelets were empty, except for traces of unidentifiable green and brown tissue.

Second, we attempted live capture of murrelets during the day with a net gun (Koda Enterprises, Mesa, Arizona) in order to lavage for prey. We searched for murrelets on 13 May (17:30–20:00) and 14 May 2002 (05:00–08:00), but no murrelets were located due to large swells and high winds (Fig. 1). Later on 14 May (08:00), we observed several murrelets near Anacapa Island (Fig. 1). We approached these murrelets at slow speeds in an inflatable boat but determined that they could

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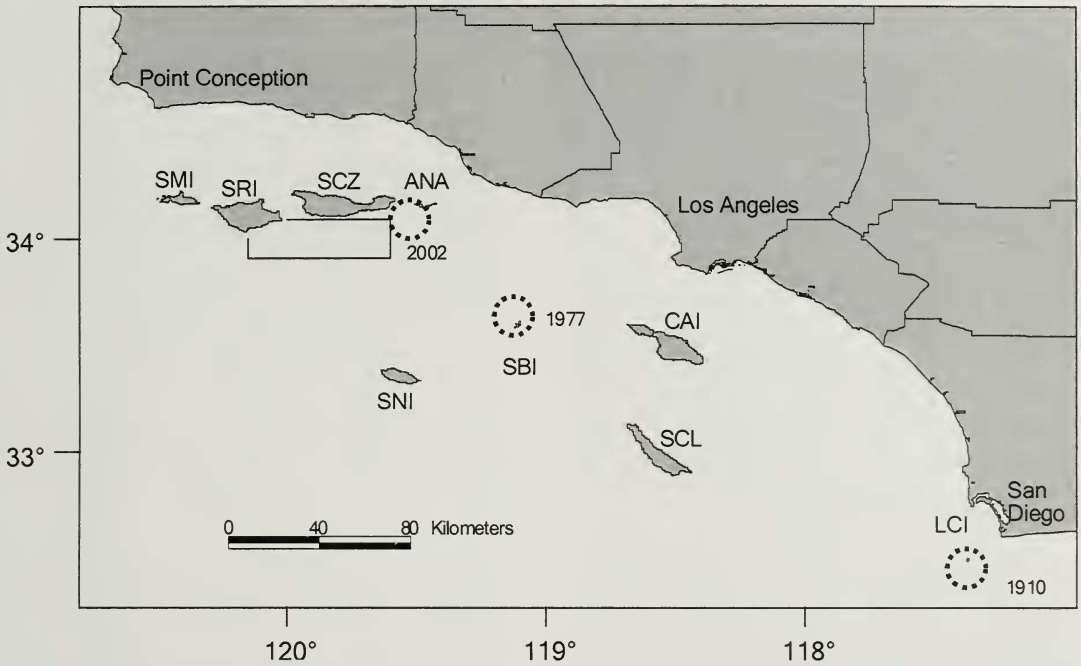

FIG. 1. Xantus's Murrelet collection areas (dashed-line circles) near breeding colonies at Anacapa Island (ANA), Santa Barbara Island (SBI), and Los Coronados Islands (LCI), within the Southern California Bight, California, in 2002, 1977, and 1910, respectively. In 2002, the boxed area was partially searched for capturing murrelets with net guns. Murrelets also breed at Santa Cruz Island (SCZ), San Miguel Island (SMI), Santa Catalina Island (CAI), and San Clemente Island (SCL), but do not breed at Santa Rosa Island (SRI) and San Nicolas Island (SNI) (Carter et al. 1992, Burkett et al. 2003).

not be captured with a net gun: they dove or flushed at distances of 40–50 m and flew less than 0.5 m above the water. For net gun capture, birds need to be within 10–20 m from the gun and fly higher than 0.5 m above the water.

After failing to collect murrelets using nonlethal techniques, we were permitted to collect 10 birds using a shot gun. The collections occurred on 14 May (09:15–11:00; $n = 3$) and 15 May (07:00–08:20; $n = 7$; Fig. 1). We approached murrelets at fast speeds in an inflatable boat, causing them to dive. When they resurfaced after one or more dives, they were shot and carcasses were retrieved immediately.

Within 15–60 min of collection, stomachs were removed and placed in 70% ethanol and bodies were frozen. Stomach contents were sorted and specific identifications were reviewed by individuals experienced with specific prey taxa. Whole and partially digested prey items were counted, total lengths of whole prey items were measured with calipers, and total lengths of partially digested prey items were estimated from partial measurements (using ratios from morphometric markers). Life stages of prey items were determined from total lengths. Preliminary identifications were checked against descriptions in the literature for lengths, life stages, morphological characteristics, and expected distribution (Baxter 1966, Horn 1973, Kathman et al. 1986, Kucas 1986, Okamoto et al. 2002).

Birds were sexed by gonad inspection. Adults were identified by large testes size, presence of ovarian follicles >1 mm (Nevins and Carter 2003), or presence of brood patches (both sexes incubate). We also gathered morphological data, collected tissues for contaminant analysis, and prepared individuals as museum specimens. Study skins and prey specimens were preserved at the Humboldt State University Wildlife Museum (Arcata, California).

RESULTS

On 14 May 2002 (Fig. 1), we observed 10 murrelets and collected 3. All murrelets were within 100 m of a large, 10-m-wide band of sea foam, floating algae, and other debris that was aligned west-to-east without obvious associated water mixing. On 15 May, we observed an aggregation of 50–100 murrelets and collected 7 more birds (Fig. 1). This aggregation of murrelets was associated with several small, west-to-east convergence lines marked with 1-m-wide bands of sea foam associated with active water mixing at the surface. Based on facial plumage, all 10 murrelets collected belong to the northern subspecies (*S. h. scrippsi*), which breeds primarily in the SCB (Jehl and Bond 1975).

In our sample, 7 of the 10 stomachs contained prey and 3 were empty. Each stomach contained only one prey species (Table 1). Single northern anchovy (subadult or adult) were found in two stomachs collected on separate days. In both cases, the head of each fish had been crushed while the bodies were relatively intact. Two stomachs collected on different days contained either juvenile bluefin driftfish (*Psenes pellucidus*) or juvenile medusafish, (*Icichthys lockingtoni*). Specific identification of these fish was impossible because they were partially digested (i.e., heads entirely disintegrated but tails intact). We narrowed identification to these fish species based on size and morphology of tail and pelvic fins. Tail and pelvic fin morphology are identical for juveniles of these two fish species, and different than that of other species in the SCB. Three stomachs contained mature euphausiids (*Thysanoessa spinifera*).

When collected, 5 of the 10 murrelets were taken from pairs, 4 were in a group, and 1 was alone. Six were adult females and four were adult males. We collected one male-female pair, wherein one stomach contained northern anchovy and the other was empty. The group of four murrelets collected together may have represented two pairs (i.e., two males and two females); three of these had fed on euphausiids while the other had an empty stomach. One of these females had recently laid at least one egg (based on the presence of a post-ovulatory follicle, enlarged oviduct, and developing brood patches), and the asso-

TABLE 1. Comparison of diet of Xantus's Murrelets collected near Santa Barbara Island, California, in 1977 (Hunt et al. 1979) and near Anacapa Island, California, in 2002 (this study).

Prey items (species)	1977 collections			2002 collections					
	Life stage	% Occ[a]	n^b	Life stage	% Occ[a]	n^b	Mean[c]	Range[c]	Range of length (mm)
Euphausiid (*Thysanoessa spinifera*)	—	—	0	Mature	43	3	8.3	5–12	25–30
Northern anchovy (*Engraulis mordax*)	Larval	42	8	Subadult/adult	29	2	1	1	95–110
Medusafish (*Icichthys lockingtoni*) or bluefin driftfish (*Psenes pellucidus*)	—	—	0	Juvenile	29	2	2.5	1–4	35–40
Pacific saury (*Cololabis saira*)	Larval	11	2	—	—	0	—	—	—
Rockfish (*Sebastes* sp.)	Larval	11	2	—	—	0	—	—	—
Unidentified fish	Larval	37	7	—	—	0	—	—	—
Empty	—	—	3	—	—	3	—	—	—

[a] % Occ = (number of stomachs with specific prey type/number of total stomachs with prey) × 100. Data from Hunt et al. (1979) were recalculated using this method.
[b] Sample size is number of stomachs containing each prey item. For the 1977 collections, sample size was calculated using percent occurrence reported in Hunt et al. (1979), and 22 total stomachs collected.
[c] Items/stomach.

ciated male had developed brood patches. None of the other murrelets had brood patches or exhibited signs of egg laying.

DISCUSSION

Until 1977, little was known about the diet of the Xantus's Murrelet. Howell (1910:185) reported that Xantus's Murrelets collected during May to July 1910 at Los Coronados Islands, Mexico (Fig. 1), "feed upon all kinds of small sea life, including crustaceans . . . [some] contain a certain green sea-weed. . . . " Dawson (1923) reported that they fed on "marine invertebrates," but no details were provided. Miller (1936) reported that one murrelet collected during July or August 1935 off San Diego contained "several small fish." One dead murrelet collected on the beach in Douglas County, Oregon, in February 1989 contained sandlance otoliths (*Ammodytes* sp.; Los Angeles County Museum #105851, collection notes).

In 1977, 19 of 22 stomachs from birds collected offshore of Santa Barbara Island contained prey, and each stomach apparently contained only one prey type (based on our calculations from percent occurrence reported in Hunt et al. 1979). Eight stomachs (42% of stomachs with prey) contained larval northern anchovies and 11 contained other fish species (Table 1).

Our 2002 sample added to the diversity of prey types and age/size classes of fish known to be utilized by Xantus's Murrelets. Anchovies—all subadults or adults—were present in 29% of stomachs. In the 1977 sample, all anchovies found in murrelet stomachs were larval. Use of euphausiids was first documented in 2002, although unidentified marine invertebrates were noted in the historical literature. *Thysanoessa* euphausiids are common prey for Cassin's Auklets (*Ptychoramphus aleuticus*) during the breeding season in the northern SCB (Hunt et al. 1979, Adams 2004) and for Marbled Murrelets (*Brachyramphus marmoratus*) during the non-breeding season in Alaska (Sanger 1987). Neither bluefin driftfish nor medusafish have been reported previously as prey species for Xantus's Murrelets. Medusafish are uncommon alcid prey but have been reported to be taken by Tufted Puffins (*Fratercula cirrhata*; Baltz and Morejohn 1977). Bluefin driftfish have not been reported previously as alcid prey. The juvenile stages of both species are associated with jellyfish and floating weed patches (Horn 1973, Okamoto et al. 2002). Their presence in murrelet diet likely reflected murrelets foraging near convergences of floating patches of debris, algae, and sea foam. These juvenile fish were much smaller than the subadult or adult anchovies found in 2002.

Radio-marked Xantus's Murrelets from Santa Barbara Island in 1996–1997 (Whitworth et al. 2000) and Anacapa Island in 2002–2003 (C. D. Hamilton unpubl. data) were reported using Anacapa Passage (between Anacapa and Santa Cruz islands; Fig. 1) in the same area where we collected murrelets. Thus, the collected murrelets could have been from several SCB breeding colonies, and Anacapa Passage may be an important foraging area for Xantus's Murrelets. The collected murrelets contained different fish and euphausiid prey species, indicating that several prey types were available in that area in mid-May 2002. Only one prey type, however, was found in each stomach in 2002 and 1977, indicating that feeding occurred on one prey type at a time. Three of four murrelets collected together were feeding on euphausiids, indicating that murrelets found together may be exploiting the same prey resources.

Synthliboramphus murrelets dive for and feed on a variety of small fish and zooplankton and are considered to be generalist feeders (Sealy 1975, DeWeese and Anderson 1976, Gaston 1992, Gaston et al. 1993, Gaston and Jones 1998). Dietary information from 1977 and 2002 breeding seasons indicated that while Xantus's Murrelets feed on a variety of prey types, northern anchovy may be the most common prey in the SCB during the breeding season. Little is known about diet during the non-breeding season (murrelets disperse as far north as British Columbia, Canada) or about diet of the southern subspecies (*S. h. hypoleucus*), which breeds off the central west coast of Baja California, Mexico.

A cool-water period from 1950–1975 had made conditions favorable for anchovy abundance in the SCB (Chavez et al. 2003), and could have led to frequent consumption of anchovies (42% occurrence) in 1977. In 1978, when the availability of larval anchovies was delayed (Lasker 1979), murrelets exhibited

delayed breeding or failed to breed. This suggests that larval anchovy abundance affected reproductive success and survival of murrelets (Hunt and Butler 1980). Larval anchovies, however, were not found in the 2002 sample; thus, overall prey abundance and availability may be more important factors influencing reproductive success and survival. Large-scale variations in water temperature that occur in the SCB are known to affect the abundance of anchovies, zooplankton, and other fish species (Roemmich and McGowan 1995, Chavez et al. 2003, Lluch-Belda et al. 2003), and these variations likely affect Xantus's Murrelets during the breeding season.

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LITERATURE CITED

Adams, J. 2004. Foraging ecology and reproductive biology of Cassin's Auklet (*Ptychoramphus a. aleuticus*) in the California Channel Islands. M.Sc. thesis, Moss Landing Marine Laboratories and San Francisco State University, California.

Baltz, D. M. and G. V. Morejohn. 1977. Food habits and niche overlap of seabirds wintering on Monterey Bay, California. Auk 94:526–543.

Baxter, J. L. 1966. Summary of biological information on the northern anchovy *Engraulis mordax* Girard. California Cooperative Oceanic Fisheries Investigations Report 11:117–135.

Briggs, K. T., W. B. Tyler, D. B. Lewis, and D. R. Carlson. 1987. Bird communities at sea off California: 1975 to 1983. Studies in Avian Biology 11:1–74.

Burkett, E. E., N. A. Rojek, A. E. Henry, M. J. Fluharty, L. Comrack, P. R. Kelly, A. C. Mahaney, and K. M. Fien. 2003. Report to the California Fish and Game Commission: status review of Xantus's Murrelet (*Synthliboramphus hypoleucus*) in California. California Department of Fish and Game, Habitat Conservation Planning Branch Status Report 2003–01.

Carter, H. R., G. J. McChesney, D. L. Jaques, C. S. Strong, M. W. Parker, J. E. Takekawa, D. L. Jory, and D. L. Whitworth. 1992. Breeding populations of seabirds in California, 1989–1991. Unpublished report, U.S. Fish and Wildlife Service, Dixon Field Station, Dixon, California.

Chavez, F. P., J. Ryan, S. E. Lluch-Cota, and C. M. Niquen. 2003. From anchovies to sardines and back: multidecadal change in the Pacific Ocean. Science 299:217–221.

Dawson, W. L. 1923. The birds of California: a complete, scientific and popular account of the 580 species and subspecies of birds found in the state, vol. 3, Students' ed. South Moulton Company, San Diego, California.

DeWeese, L. R. and D. W. Anderson. 1976. Distribution and breeding biology of Craveri's Murrelet. Transactions of the San Diego Natural History Society 18:155–168.

Drost, C. A. and D. B. Lewis. 1995. Xantus' Murrelet (*Synthliboramphus hypoleucus*). The Birds of North America, no. 164.

Gaston, A. J. 1992. The Ancient Murrelet. T. and A. D. Poyser, London, United Kingdom.

Gaston, A. J., H. R. Carter, and S. G. Sealy. 1993. Winter diet of the Ancient Murrelet off Victoria, British Columbia. Canadian Journal of Zoology 71:64–70.

Gaston, A. J. and I. L. Jones. 1998. The Auks. Oxford University Press, New York.

Horn, M. H. 1973. Systematic and distributional status of *Psenes sio* and *Psenes pellucidus* (Pisces, Stromateidae) in the Eastern Pacific. Copeia 1:167–169.

Howell, A. B. 1910. Notes from the Los Coronados Islands. Condor 12:184–187.

Hunt, G. L., Jr., and J. L. Butler. 1980. Reproductive ecology of Western Gulls and Xantus's Murrelets with respect to food resources in the Southern California Bight. California Cooperative Oceanic Fisheries Investigation Report 21:62–67.

Hunt, G. L., Jr., R. L. Pitman, M. Naughton, K. Winnett, A. Newman, P. R. Kelly, and K. T. Briggs. 1979. Reproductive ecology and foraging habits of breeding seabirds. *In* Summary of marine mammal and seabird surveys of the Southern California Bight area, 1975–1978. Vol. 3—Investigators' reports. Part 3. Seabirds—Book 2. Report for the Bureau of Land Management, Contract AA550-CT7-36. University of California, Santa Cruz.

Jehl, J., Jr., and S. I. Bond. 1975. Morphological variation and species limits in murrelets of the genus *Endomychura*. Transactions of the San Diego Society for Natural History 20:9–24.

Kathman, R. D., W. C. Austin, J. C. Saltman, and J. D. Fulton. 1986. Identification manual to the Mysidacea and Euphausiacea of the northeast Pacific. Canadian Special Publication of Fisheries and Aquatic Sciences, no. 93.

Kucas, S. T. 1986. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Pacific Southwest): northern anchovy. Biological Report 82(11.50). U.S. Fish and Wildlife Service, Washington, D.C.

Lasker, R. 1979. Factors contributing to variable recruitment of the northern anchovy (*Engraulis mordax*) in the California Current: contrasting years 1975 through 1978. ICES Symposium on the early life history of fish, Marine Biological Laboratory, Woods Hole, Massachusetts.

Lluch-Belda, D., D. B. Lluch-Cota, and S. E. Lluch-Cota. 2003. Scales of interannual variability in the California Current system: associated physical mechanisms and likely ecological impacts. Cooperative Oceanic Fisheries Investigation Report 44:76–85.

Miller, L. 1936. Some maritime birds observed off San Diego, California. Condor 38:9–16.

Nevins, H. M. and H. R. Carter. 2003. Age and sex of Common Murres *Uria aalge* recovered during the 1997–1998 Point Reyes tarball incidents in central California. Marine Ornithology 31:51–58.

Okamoto, M., H. Ida, H. Sugisaki, and Y. Kurita. 2002. Larval and juvenile development of the Medusafish, *Icichthys lockingtoni* (Perciformes: Centrolophidae), from the Northwest Pacific, and a comparison with Northeast Pacific larval and juvenile forms. Ichthyological Research 49:93–96.

Roemmich, D. and J. McGowan. 1995. Climatic warming and the decline of zooplankton in the California Current. Science 267:1324–1326.

Sanger, G. A. 1987. Winter diets of Common Murres and Marbled Murrelets in Kachemak Bay, Alaska. Condor 89:426–430.

Sealy, S. G. 1975. Feeding ecology of Ancient and Marbled Murrelets near Langara Island, British Columbia. Canadian Journal of Zoology 53:418–433.

Whitworth, D. L., H. R. Carter, R. J. Young, E. Creel, W. R. McIver, F. Gress, and S. Fangman. 2003. Monitoring of at-sea congregations and nest success of Xantus's Murrelets (*Synthliboramphus hypoleucus*) at Anacapa Island, California, in 2000–02, prior to eradication of Black Rats (*Rattus rattus*). Unpublished report, Humboldt State University, Department of Wildlife, Arcata, California (prepared for the American Trader Trustee Council).

Whitworth, D. L., J. Y. Takekawa, H. R. Carter, and W. R. McIver. 1997. Night-lighting as an at-sea capture technique for Xantus' Murrelets in the Southern California Bight. Colonial Waterbirds 20:525–531.

Whitworth, D. L., J. Y. Takekawa, H. R. Carter, S. H. Newman, T. W. Keeney, and P. R. Kelly. 2000. Distribution of Xantus' Murrelet (*Synthliboramphus hypoleucus*) at sea in the Southern California Bight, 1995–97. Ibis 142:268–279.